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REPORT ON THE EFFECTS OF FISHING ON THE PERUVIAN STOCK OF ANCHOVY

by

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PREPARATION OF THIS REPORT

This document is the original English version of a report by FAO to the Instituto del Mar del Perú. The Spanish version will eventually be published by this Institute. The report is reproduced here to give an opportunity to scientists specialising in this field for a critical study of the analyses made and the conclusions drawn.

Distribution

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Report on the effects of fishing on the Peruvian stock of anchovy

Gives summary of biological information available; analyses length, catch, effort and catch per unit of effort; estimates mortality. Discusses conclusions and gives recommendations.

PREFACE

Studies of the Peruvian anchovy fishery and of the biology of the anchovy were initiated in 1960 by the Marine Research Institute of Perú (since 1964 the Instituto del Mar del Perú) as a project of the U.N. Special Fund executed by FAO. Results of these investigations have been reported in a number of publications issued by the Institute. During the whole period of the very remarkable expansion of the fishery there has been a great demand for an assessment of the total extent of this resource. The short series of statistical data available and the lack of vital biological information has hitherto prevented such work from being carried out successfully. Hoping that adequate information would now have been accumulated, the Instituto del Mar del Perú asked FAO in April 1965 to provide expert help in an analysis of all available data. The UN Special Fund agreed to make funds available to bring Mr. L.K. Boerema, FAO Fisheries Biologist (Stock Assessment), Rome, and Mr. G. Saetersdal, Chief Biologist of the FAO/UNSF project at the Fisheries Development Institute in Chile, to Perú to work together with the scientists of the Instituto del Mar del Perú concerned with the anchovy stock assessment. Mr. Saetersdal had previously worked as biologist in the FAO/UNSF project which preceded the creation of the Instituto del Mar del Perú. The work was undertaken in June 1965, and the results of this joint effort are set out in this report.

The report is based entirely on information and data collected and processed by the Institute. Dr. H. Einarsson, FAO/UNSF adviser to the Institute, was responsible for the planning and organization of the anchovy investigations of the Institute. The authors wish to express their great appreciation for the way in which this major research task has been carried out. During the weeks in which the present analysis was made the scientific staff of the Institute, under the leadership of Dr. J. Sanchez R., was made fully available for this special task. Special thanks are due to Mr. A. Landa who translated the report into Spanish.

Rome, December 1965

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REPORT ON THE EFFECTS OF FISHING ON

PERUVIAN STOCK OF ANCHOVY

Section A. General description of findings, conclusions and recommendations

The Peruvian anchovy fishery has developed over the last 7-8 years. Research on the stock was started in 1960, but up till the present time no attempts to evaluate the resource have been successful, because of insufficient data. The assessment which has now been made is therefore the first appraisal of the extent of the anchovy stock and of the effects of fishing on this stock. The analysis is based on all biological and statistical data collected by the Instituto del Mar del Perú (previously Marine Research Institute). In the following we will first explain in simple terms the principles involved in exploitation of renewable natural resources of the type to which the anchovy belongs, and then relate the findings of the analysis contained in section B of this report and the conclusions that can be drawn from them.

The exploitation of big marine fish resources is influenced by biological laws of nature which result in a certain pattern in the history of development of such industries. From the unexploited state the fishery at first will yield total landings nearly in proportion to the fishing effort (number or capacity of boats) applied. The catch per boat per month or per trip may in the first initial period often increase as a result of increased efficiency of vessels and equipment and improvements in the technique of the fishing operations. As the fishery develops, however, and the total fishing effort reaches substantial levels the catch per unit of effort will decrease because the fishing itself affects the population. The effect is to increase the total mortality rate of the fish, thus reducing the total abundance of the fish, the average life-span and the mean size of the fish in the catches. Further expansions of the fishery may lead to a state where additional effort in the form of new boats or better fishing equipment does not any more result in an increase of total catch by weight. Then the maximum total yield of the resource has been reached, and beyond this point the total catch may decline if further effort is applied because then too many fish are caught when they are still small and their weight very low. Sometimes the adverse economic effects of the decline in catch per unit of effort are so severe that the expansion of the total effort stops before the overall maximum catch is reached.

This history of development of a fishery is unfortunately not always clearly evident from the simple statistical data of the industry. Fluctuations in the availability of the fish from year to year, which may be caused by changes in the natural environment, may obscure the trends in catch per unit of effort. Natural fluctuations and trends in the total size of the stock may occur as well and they will also produce fluctuations of catch and catch per unit of effort which for some time may overshadow the effects of fishing on the stock. For these reasons relatively long series of statistical data are needed to make an assessment of the magnitude of a fishery resource, based on such data alone. But if the statistical data of the fishery can be supplemented with biological information from the fish population, the effects of fishing can often be distinguished and measured at a much earlier stage.

The annual landings of the anchovy fishery have increased continuously until now together with the steadily increasing investments in this industry. But the catches have not risen in proportion to the fishing effort throughout the period. From the year 1962 onwards a notable decrease of catch per unit of effort has taken place. The success of the fishery varies somewhat from port to port, but the decline in catch per vessel per ton capacity is considerable over the last years when the gross data for the whole fishery are analysed. Another indication of the decreasing abundance of the anchovy in the ocean is the increasing number of trips without catch of the fishing vessels that has been recorded in later years and the decline in the mean total number of working days per vessel in most ports. These observations suggest that the fishing might have affected the stock to a notable degree.

A further step in demonstrating the effects of fishing on the anchovy stock could be taken when biological investigations showed that the abundance of each year-class or recruit-class may vary considerably from year to year, and that these variations can be measured. An important result of this finding was that the success of the fishery of each season could be related to the initial abundance of the recruit-class on which that season's fishery was based, and the effects of the natural fluctuations on stock abundance could thus be separated from those arising from the fishing itself. The anchovy first enter the fishery in January till May at an age of 5-9 months when their size is 8-11 cms. The abundance or strength of the new recruit-class can then be estimated. The main bulk of this recruit-class is, however, fished in the next following season from October - November till June - July when their age is from about 1½-2 years and their size 13-16 cm. A recruit-class will thus dominate the fishery in the season after it made its first appearance.

When analyses were made allowing for the natural fluctuations in the initial abundance of the recruit classes it became evident that the total catch by weight per unit recruitment increased from the recruit-class 1961 to that of 1962 or 1963, but the estimates for the recruit-class 1964 are similar to those for the class 1963. This would in effect mean that the fishing effort used in the season 1963 was already big enough to ensure the maximum total catch of the stock. The increase of the total annual landings since 1963 was mainly caused by the specially abundant recruit-class appearing in 1964.

It is necessary to state here that the identification of the recruit-classes which is based on certain biological findings may not have been completely achieved. A bias may exist in the data, and this would result in an overestimation of the effects of fishing over these years. It is unlikely, however, that this bias is very big. There is further evidence that a state of the fishery has been reached where additional effort will result only in an insignificant increase of total catch and in further marked declines of catch per unit of effort. The mean size of the fish in the catches has decreased considerably over the last years from 18.5 grams for the recruit-class 1961 to 15.0 grams for the recruit class 1964. Whereas fishing accounted for something like 1/4 of the total number of deaths in the anchovy stocks in 1961, this figure rose to the order of 2/3 in 1963/64. When relating the value of the latter ratio to the information available on the life-span, the growth-pattern of the anchovy, and the size of the fish when being recruited to the fishery, the conclusion must again be drawn that the fishery is being conducted with an effort that nearly corresponds to that which will theoretically give the maximum total yield. It is thus concluded that the fishery cannot be much further expanded. If more vessels are added to the fleet the result will be a decline of the catch per vessel, and the total catch per unit recruitment may remain about the same or even decrease.

The data on which the above conclusions have been based cover only a short period of time, and some essential biological data for a complete analysis are still lacking. Therefore, the conclusions reached here should be considered as subject to revision. Some specific reservations are outlined on page 20 and 21 of section B.

Thus, the assessment made above does not provide a full and complete basis for a rational management of the industry. Notwithstanding these reservations, it is believed that the present conclusions are sufficiently firm and well documented to provide a general basis for a policy of management.

Recommendations

Further increase of effort above the present capacity of the fleet would at best lead only to a minor increase of total catch per unit recruitment, and possibly even to some decrease, and it would result in a further decrease of catch per unit effort (e.g. per vessel). It is therefore recommended that such a further increase in effort should not be allowed.

Both a closed season (apart from the effects of the protection of young fish, as discussed in a following paragraph) and catch limitation, may limit the total fishing effort. They do, however, not directly affect the number of boats working. Because fishing effort is not so high that the level of maximum yield of the anchovy has been passed, the effect of such measures, if any, would be that not only the total landings, but also the annual catches of anchovy per ship would decrease if the fleet maintains its present size. Therefore, neither a closed season nor a substantial catch limitation can be recommended. If, however, a quota set high enough not to limit the total catches to a level substantially below the maximum sustainable yield might discourage further expansions, or encourage limitation of the capacity of the fleet introduction of such a quota could be useful.

The only effective measure of effort regulation by which the annual catches per boat of standard efficiency can be increased above the level ocurring if no regulation would take place, is through a regulation of the total fishing capacity of the fleet. As a first step in this direction it is recommended that the total fishing capacity of the fleet be not permitted to rise above its present level. It is also recommended that studies be undertaken on the expected effects of a reduction of the total fishing capacity of the fleet in its various aspects. It is furthermore a matter of great importance for the state of the industry that the production capacity of the fish meal plants is kept in a reasonable relationship to the availability of the raw material. It is therefore recommended that the feasibility and desirability of a regulation of fish meal plant capacity be investigated.

It is doubtful whether an increase in the minimum size of the fish caught (i.e. protection of the small-sized fish by raising the minimum landing size or by a closed season in periods of large catches of small fish) would lead to any appreciable increase in total catch per unit recruitment and, in fact, it might even lead to a decrease. It is therefore not recommended to introduce this type of regulation at present, but this question should be reviewed when further data become available in the future.

Natural fluctuations of the recruitment will lead to fluctuations in the total annual catches in future years. If recruitment is twice as high as normal, the catch and the catch per unit effort of the recruit class will also be twice as high; and if recruitment is only half the normal, the catches will also be half. But in all situations about the same total effort will give the maximum catch from the stock that is available in the sea. The recruit class of 1965 appears to be considerably less abundant than that of 1964 and it is expected that this may adversely affect the total catch in the coming fishing season. Fluctuations in catch due to variations in availability as an effect of changes of the environment in which the fish live, will also occur. The variations in catch and catch per unit of effort resulting from these two causes must be accepted as inherent in the exploitation of marine fisheries resources.

Section B. Analysis

1. Introduction

This section describes in more detail the analysis of the data on the fishery and biology of the Peruvian anchovy (Engraulis ringens J.) on which the findings reported in section A. have been based. Much of the work contained in this section is a follow-up of the investigations published by Saetersdal, Tsukayama and Alegre (1965). Reference is made to their paper for a more detailed description of the fishery and the fishing fleet and of some of the methods and terminology used in the present report.

2. Summary of biological information available

The information presented in this chapter is drawn from the publications listed in the references.

The parameters of the Bertalanffy growth function (see Gulland 1964) have been found to be $K = 1.7$, $l_\infty = 15$ cm. Mean lengths at age intervals are : 9 cm at ½ year, 12 cm at 1 year, 13-14 cm at 1½ years. The life-span is probably about 2 yea

Maturity is reached at about 12 cm of length. Spawning occurs from August to February with a main peak season in August-September and a lesser mode in February. The first recruitment to the fishery of a new brood occurs mainly from January to May at the age of 5-9 months, and at a total length of 8-11 cm. The availability (or catchability) of the fish is low during winter (July-September) and high during spring and summer, but with a secondary short low period, usually in February-March. The fluctuations in availability are reflected in the curve of the catches by months which are always bi-modal over yearly periods. The reduced availability might possibly be associated with spawning behaviour.

The fluctuation of availability affects the average size and age of recruitment to the fishery. A recruit-class is fished more intensively between 6-9 months of age and after 15 months of age than between 9-15 months. The class is probably not fully recruited to the fishery until the age of 15 months, and this may account for the unusual shape of the length-catch curves and length-abundance curves which are bi-modal with a low left-hand and high right-hand mode.

Recruit-classes have been found to fluctuate considerably in abundance from year to year, and corresponding variations in the abundance of the adult fish (13-14 cm and above) have been demonstrated. A vital point in some of our analyses below has been to adjust for the fluctuations in recruitment which otherwise would complicate greatly the interpretation of the data.

Evidence from the size-distributions and the fluctuations in recruitment suggests homogeneity of population structure within Peruvian waters, but especially for the area between Chimbote and Callao. Vertebral-counts give no evidence of stock heterogeneity, but significant differences in gill rakers are found between the southern port Ilo and the Callao-Chimbote area.

Results of exploratory echo-surveys, as well as evidence from the fishery, show hat the distribution of the anchovy is limited to the cool up-welling waters of the oastal area (temperature range 14 - 17°C) which seldom extend more than 60 - 100 autical miles from the shore. Intrusions of oceanic warm sub-tropical water towards he coast have been shown to affect the distribution of anchovy and thus the availa-ility of the fish to the fishery.

General statistics

3.1 Total landings

The annual landings of anchovy have increased continuously until 1964, but with only a minor increase from 1962 to 1963. This is shown by the data in Table 1. Because no detailed biological information is available from the area south of Callao, some of the analysis below had to be carried out on the data for the fishery in the area from Callao to Chimbote only. Therefore, the table also includes the annual landings in this area. It can be seen from the table that the catches in the area south of Callao constitute only a minor part of the total landings.

TABLE 1. Annual landings of anchovy by the whole Peruvian fishery, and annual landings in the area Callao-Chimbote only, for the period 1959-1964 (Quantities in '000 tons).

Year	Total Annual Landings	Annual Landings in the area Callao-Chimbote
1959	1,909	1,840
1960	2,944	2,796
1961	4,580	4,368
1962	6,275	5,938
1963	6,419	5,947
1964	8,863	8,019

3.2 Fishing effort

Table 2 shows the development of the fishing fleet, in number and capacity of the vessels.

The numbers are given as the total number of boats known as having been working in the course of each year (Column A). Because the fleet was expanding the figures in fact represent the approximate number of vessels actively engaged in the fishery at the end of each year.

The capacity of the fleet (Column B) is expressed as the total holding capacity (in tons) of the ships included in Column A. Saetersdal, Tsukayama and Alegre (1965) have shown that the relation between holding capacity and annual landings per ship is practically proportional. The total holding capacity therefore, represents the total fishing capacity of the fleet.

Both the number of boats and the total capacity, show a considerable increase in the period 1959-1964, the increase in capacity being greater than that in the number of boats due to the increased average capacity per boat shown in Column C.

TABLE 2. Development of the fishing fleet.

Year	A Total N° of boats working at the end of each year.	B Total holding capacity at the end of each year (tons).	C Average holding capacity per boat at the end of each year (tons).
1959	433	25,638	59.2
1960	709	51,620	72.8
1961	878	68,730	78.3
1962	1,096	99,000	90.3
1963	1,756	176,000	100
1964	1,846	192,000	104

In order to obtain a measure of the activity of the fleet, the number of days at sea (working days, total number of trips) was estimated. Information was available on the total number of landings per month (total number of trips with catch). On the basis of log books of ships from the ports Callao, Huacho, Supe and Chimbote, and some information supplied by fishing companies, covering the years 1961-1964, monthly estimates could be obtained of the percentage of the number of days at sea without catch. From these data, estimates were made of the total number of working days of the whole fleet. By dividing these totals by the number of boats, the number of working days per boat, and the number of trips with catch per boat were estimated. For this purpose the number of boats in each year has been taken as the average of the number present at the end of that year and at the end of the previous year.

These data are included in Table 3.

TABLE 3. Activity of the fleet.

Year	N° of trips with catch ('000)	Trips without catch in % of total working days	Estimated total N° of working days ('000)	N° of trips with catch per boat	N° of working days per boat
1959	56.1				
1960	81.0				
1961	111.0	15.6	131.6	140	166
1962	125.0	18.7	153.8	127	158
1963	131.4	34.1	199.4	92	140
1964	160.6	29.6	228.1	89	127

The table shows that both the total number of trips with catch, and the total number of working days, have increased considerably, although the number of trips with catch, and of working days, per boat, have decreased and the percentage of trips without catch has increased (the latter with the exception of 1964).

A first estimate of the total fishing effort has been obtained by multiplying the total number of working days by the average capacity per boat in

each year. Allowance still has to be made for the increased efficiency of the vessels, due to the use of larger nets and power blocks. Saetersdal et al (1965) described the corrections they made for allowing for this efficiency increase. It was, however, considered desirable to revise these correction factors.

The revised figures were arrived at in the following way. Saetersdal et al (1965) estimated that the observed tendency for ships of a given size to use larger purse seines would have led to an annual increase of the fishing efficiency of the vessels by about 3% per year.

Using recent data on the size of the purse seines, and using the same criteria, the following estimates of increase in net efficiency were obtained:

Year	1959	1960	1961	1962	1963	1964	1965
Increase of efficiency	0	3	6	9	11	13	15%

However, these data should be adjusted for the increased number of trips without catch, on the ground that the increase of efficiency because of the larger nets only functions when catches are actually made, and in contrast to the size of the ship does not bear a relation with the searching efficiency. It is thought that the percentage number of trips without catch is a measure of the proportion by which the net efficiency has to be decreased in order to obtain an estimate of the efficiency change of the fishing operations. Data on the percentage of trips without catch are, however, not available for the period up to 1961, whereas the efficiency correction will be needed for a longer period. Use is made, therefore, of an empirical relationship between the abundance index of the fish (as described below) and the number of trips without catch.

This led to the following estimates of increase for fleet efficiency due to the use of larger nets:

Year	1959	1960	1961	1962	1963	1964	1965
Increase of efficiency	0	2.5	4	7	8	9	10%

A revision has also been made of the estimate of the effect of the increased use of power blocks on the efficiency. This revision, based on more complete data on the number of power blocks in use is recent years, led to the following estimates:

Year	1962	1963	1964	1965
Increase in efficiency due to power block	4	5	7	8%

The total increase in efficiency of the fleet has therefore been:

Year	1959	1960	1961	1962	1963	1964	1965
Total increase of efficiency in %	0	2.5	4	11	13	16	18%

Table 4 shows the estimates of the total fishing effort in the years 1961-1964 obtained by multiplying the total number of working days of the fleet by the average capacity of each boat, and also the estimates obtained by applying to these figures the correction factors for efficiency.

A third estimate of fishing effort is obtained by using a method described by Saetersdal et al (1965). They estimated the catch per month of those vessels which had made more than 9 trips in each month, thus excluding the varying

number of boats making only occasional trips. A total effort can be estimated from these data by raising the effort of the vessels included in this analysis, expressed in total G.R.T. of these vessels per month, by the ratio of total landings to the landings of these vessels. In this way, the increase in size of the boats was allowed for. Also, the increase in efficiency of the fishing operations was taken into account. The results are given in Column D of Table 4. Because the effort in this estimate has been expressed in quite different units, the actual figures in this column are different from the previous ones. The important matter, however, is the relative increase of the effort in the period under consideration, and the data show a very great similarity in the increase in fishing effort in recent years between the results of the two different methods of appraisal.

Both results show that the total fishing effort on the anchovy stocks has increased by more than 2.5 times from 1961 till 1964.

TABLE 4. Estimates of total fishing effort

	A	B	C	D	E
Year	Total N°of trips (working days) x average capacity per boat ('00000)	Efficiency factor	Corrected Estimate (Column AxB)	Total effort estimate based on monthly landings per vessel making more than 9 trips per month in the region Callao-Chimbote ('000)	As Col. D, but effort estimate for area Callao-Chimbote only ('000)
1959		0		115.0	94.5
1960		1.025		235.9	224.0
1961	98.7	1.04	102.6	370.1	353.4
1962	132.3	1.11	146.9	512.0	484.5
1963	191.4	1.13	216.3	766.4	710.0
1964	232.7	1.16	269.9	1,002.4	906.9

It is difficult to give any estimate of the precision of the applied correction factors for efficiency. It is possible that the assumption that the fishing power of the vessels is proportional to the holding capacity or gross register tonnage, has led to an over-estimate of the increase in total fishing effort in recent years. This, however, will have been counteracted by the fact that no allowance could be made for the effect of various practically immeasureable factors increasing the fishing effort of the fleet in a developing fishery, such as increased experience of the fishermen, slight modifications in gear and methods of fishing, the introduction of modern techniques and equipment for the location of the fish, etc. which in itself would have caused our estimates to be lower than the real values. It has, therefore, been taken that the values contained in the columns C - E are the best estimates available at this moment.

3.3 Catch per unit of effort.

Column A, C and D of table 5 give the data of the total annual landings

divided by the various estimates of fishing effort shown in the corresponding columns of table 4, and thus provide estimates of the catch per unit of effort obtained from the different estimates of fishing effort.

TABLE 5 Estimates of catch per unit of effort, from effort estimates given in table 4

	Catch per day (tons) for ships with a holding capacity of 100 tons		Catch per G.R.T. per month (tons) for ships with more than 9 trips per month		
	Column A	C	D	F	G
1959			16.6	20.5	13.5
1960			12.5	17.4	20.2
1961	46.4	44.6	12.4	16.9	19.8
1962	47.4	42.7	12.3	17.8	18.2
1963	33.5	29.7	8.4	9.5	14.8
1964	38.1	32.8	8.8	9.2	10.5

One further estimate of catch per unit of effort is that derived from the monthly performance of vessels with more than 9 landings in a port, using the mean catch in tons per month per gross register ton of the vessels, adjusted for change in efficiency and also for the effect of vessel saturation. The mean annual values of the monthly c.p.u.e. data thus obtained were averaged for the ports Chimbote, Huarmey, Supe, Huacho and Callao and are shown in column F of table 5. The annual means for the port Ilo are shown separately in column G. These measures of catch per unit effort were used to estimate the length-abundance compositions.

All estimates agree in showing the tendency of decline through the period under investigation, but the three first show an increase from 1963-1964.

Analysis of length compositions.

4.1 Introduction.

Observations on the size and numbers of the fish in the catches are important for stock assessments because increased mortalities in the population are usually accompanied by a reduction in mean size and an increase in the numbers caught, and because size-compositions can also be used for identification of year classes in the absence of direct age-data. An analysis has therefore been made of the available length composition data. Descriptions of the terms and methods used in the following sub-sections are given by Saetersdal and Valdivia (1964).

4.2 Annual length abundance curves.

The annual length - abundance curves based on data compiled by months give an overall picture of the relative abundance of the various sizes of anchovy in the years 1961-1964. Summaries using annual figures from March one year to February the next year, are shown in figure 1. The curves of all three ports Chimbote, Callao and Ilo show evidence of a decline of abundance of big adult fish of sizes 13 - 16cm in the later years. It would be of great importance to be able to relate the abundance by numbers and weight of anchovy in various years to the fishing effort to which the fish have been exposed. However, in order to make a useful comparison of this type based on the data of length compositions it is necessary first to split the fish by year - classes and then adjust their abundance for the fluctuations that occur in the initial abundance of the group, the recruitment variations.

4.3 Separation of the recruit-classes.

In previous reports two slightly different measures of recruitment have been used: the modal abundance of the young-fish-group during the first months when they enter the fishery, and the total abundance of the group using a probable upper size-limit for each month to separate the new recruits from fish of last year's recruitment (see Saetersdal and Valdivia 1964). As the latter method seems to give more consistent results it has been used in our present analysis. Recruitment - strength is thus measured as the abundance of the young fish group by summing data for the three months of highest abundance between January and July. When two recruit groups appear during one season they have been added together. The size distributions and abundance indices that were used are shown in Annex table I and the size - limits chosen to identify the recruit group are listed in Annex table II. The figures for recruitment strength were rounded to figures with few numerals to be used as recruitment indices.

The abundance of the adult fish was estimated in the same way as for the recruit-groups applying probable size - limits assessed from the monthly length frequency distributions (Annex table II). The resulting recruit-strengths, as well as the mean adult fish abundances from November one year to May the following year, are tabulated in Annex table III. The mean values for the two ports Callao and Chimbote are plotted in figure 2, and the points are joined by lines to show the tendency of the variations. Recruitment decreased from 1961 to 1962 with a further decrease in 1963. It is seen from the graph that the abundance of adult fish also shows a decline over a two-year period from the season November 1961 - May 1962 to the season 1963/64. In 1964 the recruit abundance was high. This was followed by an increase in the abundance of the adult fish during the season 1964/65. The relationship between the abundance of the recruits one year and that of adult fish the next season can more easily be studied in figure 3 where the two indices are plotted one against the other. If fluctuations in recruitment give cause to similar fluctuations in the adult stock, one would expect the points to fall along a straight line passing through the origin, and the first three points are not very far from such a line. The straight line relationship can, however, only be expected if the total mortality in the stock has remained unaltered during the period of observation. If mortality increases, and this surely must have been the case in the anchovy stock, we would expect the abundance of the adult fish to fall off in relation to that of the recruits. The plots for the later years demonstrate this tendency.

The relationship thus shown to exist between the abundance of the recruits and that of the adult fish in the following season supports our identification of the adult group of fish during the season November to May as being mainly derived from the recruitment one year earlier. Recent interpretation made by Dr. Einarsson of otolith ring frequencies conforms with this age estimate. Using this as a working hypothesis a study was made of the size-compositions of the catch and of the size-abundance curves, both of the whole recruit-classes (i.e. all the fish originating from one recruitment, or one spawning period). This enables one to assess the total catch by numbers and weight of each recruit class and the mean length and weight of the fish caught.

4.4 Catch and abundance by recruit-classes

Two somewhat different sources of information can be made use of in this analysis. One is the monthly length-catch curves which are calculated from the total monthly length-compositions adjusted to the estimated total number of fish caught in the respective port. The total number caught is estimated as

the total monthly landing divided by the mean weight of the fish in the samples. The length - catch curves are then split up in accordance with the size - limits identifying the recruit-classes (see Annex table II), and summed up to give the total length - catch curves of each class (see fig. 4). Applying the length - weight relationship (see Annex table IV) the total estimated catch by weight and the mean weight of the fish can be calculated.

Annex table V shows the data analysed in this way.

The other method which can be applied makes use of the monthly length-abundance curves. These are split up by use of the size limits identifying the groups, and an overall size-abundance composition can be derived for the whole period during which the recruit-class is being fished. From these the total abundance by numbers and weight can be estimated, as well as the average weight of the fish (see Annex table VI).

In the following section the relationship will be studied between the catch and abundance of the various recruit-classes and the fishing effort to which they have been exposed. Here, attention will be drawn only to the declining trends evident in the data for mean length and mean weight of the recruit classes 1961 to 1964. The figures averaging the ports Callao and Chimbote are given in table 6.

TABLE 6 Mean length and weight of fish caught, by recruit classes.

Recruit-class	From length catch curves		From length abundance curves
	length	weight	weight
1961	13.74 cm	18.54 grms.	18.66 grms.
1962	13.50 cm	18.24 grms.	17.38 grms.
1963	12.82 cm	15.43 grms.	14.99 grms.
1964	12.58 cm	15.02 grms.	15.53 grms.

These declines are most probably an effect of the increasing total fishing effort over these years, which has brought about a reduction in average life-span and thereby a reduced mean size of the fish in the stock.

We are not confident that we have achieved a complete separation of yearclasses by this simple method. In particular it seems probable that our adult fish group during the first years will have contained a certain number of fish that survived from the previous recruit class. Both the total size - composition and the otolith - ring analysis indicate the presence of such older fish. Their number will be small relative to that of the total group, but their presence will result in a bias in the direction of over-estimating the decline catch per unit of effort. This bias will to some extent be compensated for by the fact that we only follow the recruit-classes until September in their second year of life (1.5 year after recruitment and 2 years after spawning) and fish that survive this age will be excluded. With steadily increasing effort the overall effect would probably be only a small overestimate of the decline of the catch per unit effort from one recruit class to the next.

Relationship between catch, effort and catch per unit of effort.

5.1 Analysis of annual fishing data

A rough estimate of the relation between fishing effort, total catch and catch per unit of effort can be obtained from the data for effort, catch and

catch per unit effort given in tables 1, 4 and 5 in section 3. They show that the increase in total fishing effort has been accompanied by an increase of the total landings, but also by a decrease of the catch per unit of effort. The latter is not bad in itself, because the potential yield of a fish stock can only be obtained at the expense of a catch per unit of effort being rather lower than that in a fishery which is only lightly exploiting a stock. It shows, however, that fishing is already exerting an important influence on the stock abundance.

The real relationship between fishing effort and catch may however be obscured in the above data because the catches are also to a large extent dependent on the sizes of the yearclasses of the anchovy as has been explained in section 4. In the next section an attempt has been made to allow for the effect of recruitment.

5.2 Analysis of annual fishing data adjusted for recruitment

In section 4.3 a method is described to separate the numbers of anchovy in the catches according to the recruitment class to which they belong. By following this method, and converting the length data into weight by applying the length - weight relationship given in Annex table IV, it was possible to separate for each calendar year the quantity landed of fish recruited the previous year and the quantity obtained from the recruitment in the actual year of fishing. The following estimates were obtained for the landings in Callao and Chimbote.

In 1962	caught	of	recr.	class	1961	2,089,000	of	recr.	class	1962	1,899,900	tons
" 1963	"	"	"	"	1962	2,155,640	"	"	"	1963	1,377,140	"
" 1964	"	"	"	"	1963	1,078,640	"	"	"	1964	3,569,850	"

Section 4.3 also gives a description of the method used to obtain recruitment indices of each recruit class. In order to calculate an overall recruitment index for each calendar year the following formula was applied.

$$\frac{\text{quantity caught, recruited in the previous year}}{\text{total quantity caught}} \times \text{recruitment index in previous year} +$$

$$\frac{\text{quantity caught recruited in year of fishing}}{\text{total quantity caught}} \times \text{recruitment index in year of fishing} =$$

overall recruitment index

Dividing the total quantity landed by this overall recruitment index gives an estimate of yield per unit of recruitment.

Because the overall recruitment index was calculated from data for Callao and Chimbote only, the data on total quantity landed used in this calculation concerned the landings in the area from Callao to Chimbote only. The results are given in table 7.

This table shows that the yield per unit of recruitment was higher in 1963 and 1964 than in 1962, but that the figures for 1963 and 1964 are practically the same. This means that the increase in fishing effort from 1963 to 1964 as shown in section 3, table 4, has not resulted in any appreciable increase in catch. The rise in the landings from 1963 to 1964 has been due wholly to the good recruitment class entering the fishery in 1964.

TABLE 7 Total landings in the area from Callao to Chimbote, estimated overall recruitment index, and yield per unit of recruitment

Year	Landings (1000 tons)	Overall recruitment index	Yield per unit of recruitment (1000 tons)
1962	5,938	6.6	900
1963	5,947	5.1	1166
1964	8,019	6.9	1162

5.3 Analysis of the data by recruit classes

Another method to correlate the yield with the effort is to estimate the total effort exerted on each recruit class throughout its life-span and the total yield of each recruit class.

For this purpose the data on fishing effort per month were used, being obtained from the catch data of vessels which made more than nine trips per month as referred to in section 3.2. The landings by weight and number per recruit class per calendar year in the ports Callao and Chimbote were raised by the proportion of the total landings in the total area Callao to Chimbote and in these two ports, in order to arrive at estimates of the total landings per recruit class in the whole area Callao to Chimbote. The results are given in table 8.

Table 8 Estimates of total catch in numbers and in weight of each recruit-class of catch per unit of recruitment, and estimated total fishing effort in the whole Chimbote-Callao area. Recruit-class followed from January one year to September next year, effort from January one year to May the next year.

Recruit class	Numbers $\times 10^6$	Recruitment index	Yield in numbers per unit of recruitment $\times 10^6$	Total fishing effort ('000)
1961	309,883	7.2	43,039	554
1962	354,312	6.0	59,052	777
1963	266,099	3.7	71,919	1189
1964	583,660	7.9	73,881	1373

Recruit class	Weight in '000 tons	Recruitment index	Yield in weight per unit of recruitment/ ('000 tons)	Total fishing effort ('000)
1961	5,569	7.2	773	544
1962	6,452	6.0	1,075	777
1963	4,126	3.7	1,115	1189
1964	8,765	7.9	1,109	1373

Figure 5 shows the plots of the data from table 8. It is seen that whereas the catch by numbers has increased with increasing effort, the total catch by weight per unit recruitment has maintained about the same value since recruit class 1962.

A similar analysis can be made of the data for total abundance of the recruit classes (See Annex table VI,) estimating total catch by multiplying the abundance by the total effort. This method will only give unbiased values for comparison between years if the distribution of the effort within each year bears essentially the same relationship to abundance over the period in consideration. Table 9 shows the data which have been plotted in figure 6. The distribution of the plots in this graph differs from that in figure 5 mainly in showing a greater increase of the catch per unit recruitment from the recruit-class 1962 to the recruit-class 1963, and in the position of the points representing the catches of the recruit classes 1963 and 1964 by numbers. Both graphs agree in showing that the increased effort spent on the yearclass 1964 did not result in greater catches by weight than would have been obtained if the fishing effort of the level of 1963 would have been applied.

As mentioned in the previous section, we are not wholly confident that a complete separation of recruit-classes has been achieved in this exercise. Some bias may exist which would be in the direction of overestimating the catch of the first years. It seems justified however, to conclude that the fishery in later years has reached a state where further increases of effort do not lead to any substantial increase in total catch.

TABLE 9. Estimated abundance in numbers and by weight of each recruit class per unit of recruitment and catch per unit of recruitment in the Callao-Chimbote area. Data from length-abundance compositions (Callao and Chimbote together).

	A	B	C
Year	Abundance in numbers per unit recruitment	Effort ('000)	Estimated catch in numbers per unit recruitment A x B ($x10^6$)
1961	67,839	544	36,904
1962	63,373	777	49,241
1963	56,221	1189	66,847
1964	45,807	1373	62,892

	A	B	C
Year	Abundance in weight per unit recruitment (Kg)	Effort ('000)	Estimated catch in weight per unit recruitment A x B ('000 tons)
1961	1,266	544	689
1962	1,108	777	857
1963	841	1189	1000
1964	712	1373	977

Estimates of mortality

6.1 Introduction

The conclusions reached in the previous sections are based on an analysis of the statistics of data on landings and effort, and on biological statistics, including length-distributions of the anchovy in the catches etc. Although correction factors have been applied for changes in the fishing efficiency of the vessels, and for the fluctuations in the magnitude of recruitment in different years, it is still possible that the data and the conclusions have been affected by undetected trends in recruitment or in fishing efficiency. Changes in availability may also have taken place. In order to strengthen the conclusions reached hitherto, assessment of the magnitude of the mortality rates, both those due to fishing and due to natural causes, in the successive years of fishing was attempted. A most powerful tool for such estimates is the analysis of data on the age-composition of the fish in the landings. However, the problems of age-determination in the anchovy have not yet been completely solved (see section 6.5). Therefore, various other approaches have been tried to estimate either total mortality or fishing mortality, or the ratio of fishing mortality to total mortality (the exploitation rate).

6.2 Estimate of the exploitation rate from information on predation

The quantities of anchovy caught by the fishery are known. If it would be possible to estimate the absolute magnitude of deaths of anchovy by predation, at least a minimum value of the ratio of natural deaths to deaths caused by fishing could be obtained.

Important predators on the anchovy stocks are the guano birds. Jordán (1965) has estimated the number of birds, mainly cormorants, gannets, and pelicans, as varying between 12 and 18 million in the years 1961-1963, and the quantity of anchovy consumed annually by these birds at between 1.8 and 2.8 million tons. Another predator of the anchovy is the bonito. Nearly 100,000 tons of this species are caught annually in Peruvian waters. If it is assumed that these fish have needed for their growth about 10 times their weight in food, and that this food mainly consists of anchovy, this adds another million tons to the figure of predation. Taking into account that other animals, e.g. squids, are important predators, it can safely be assumed that the annual natural mortality of anchovy amounts to at least 3 million tons and possibly considerably more. This means that in the year 1964, with total landings of nearly nine million tons of anchovy the ratio of deaths caused by fishing to the total deaths by all causes, the exploitation rate, will not have exceeded a figure of $\frac{9}{9+3} = 0.75$ and probably has been lower than this figure.

6.3 Estimate of the exploitation rate from the total numbers caught

Theoretically, the total number of fish caught (C) of a certain year-class during its life-span, equals the number of recruits (R) of that year-class multiplied by the exploitation rate (E) which is the ratio of the fishing mortality rate (F) to the total mortality rate (Z, or F + M), or $C = \frac{F}{F+M} \times R$.

Data on the total number of fish caught of each recruitment class, and the strength of recruitment, are estimated as described in section 4. However, data on R are not available in absolute numbers, but only in index values showing the relative strength of recruitment. But if we assume that F is proportional to the available figures on fishing effort, and that M is constant in different years it is still possible to estimate the value of $\frac{F}{F+M}$ $(= E)$ on the basis of data of a number of years with different fishing efforts, in the following way:

$$C_1 = \frac{F_1}{F_1 + M} \times R_1 \qquad \frac{C_1}{R_1} = \frac{F_1}{F_1 + M}$$

$$C_2 = \frac{F_2}{F_2 + M} \times R_2 \qquad \frac{C_2}{R_2} = \frac{F_2}{F_2 + M}$$

$$\frac{\frac{C_1}{R_1}}{\frac{C_2}{R_2}} = \frac{\frac{F_1}{F_1 + M}}{\frac{F_2}{F_2 + M}} \qquad \frac{C_1}{C_2} \times \frac{R_2}{R_1} = \frac{F_1}{F_2} \times \frac{F_2 + M}{F_1 + M}$$

The ratio $\frac{R_2}{R_1}$ equals the ratio of the recruitment indices.

$F_1 : F_2 = \text{effort}_1 : \text{effort}_2$. $\quad F_2 = \frac{F_1 \times \text{effort}_2}{\text{effort}_1}$

By substituting F_2, the only unknowns in the equation are F_1 and M, and the ratio between those can be calculated. From that follows the ratio

$$\frac{F_1}{F_1 + M}$$

The data used for these estimates are the total numbers caught of the recruit classes 1961-1964 from January in the year of recruitment until September of the following year, and the effort used covered the months January till May of the next year. The catches in the months June-September are always small, and for the group recruited in 1964 the catches in June-September 1965 had to be estimated. The data relate to the fishery in the area from Callao to Chimbote (effort data based on ships with more than 9 trips per month).

The calculations were carried out for all possible combinations, which in this case resulted in three estimates of E for each year. These figures were averaged and the results are given in table 10.

The variation in the obtained values shows that the figures of E should not be taken as very precise estimates, but anyway they show the great increase in the fishing mortality in the years since 1961, and indicate that the fishing mortality in the last two years accounts for something of the order of 2/3 of the total number of deaths in the anchovy stocks.

TABLE 10 Estimate of E from data on numbers caught

Recruitment year	Recruitment index	Numbers caught per unit of recruitment	Fishing effort	E Calculated	E Average
1961	7.2	43,039	544	0.096	
				0.259	0.22
				0.309	
1962	6.0	59,052	777	0.133	
				0.483	0.38
				0.536	
1963	3.7	71,919	1189	0.433	
				0.591	0.61
				0.800	
1964	7.9	73,881	1373	0.530	
				0.673	0.67
				0.828	

6.4 Attempt to estimate the total mortality rate from the decline in average weight of the fish in the landings

With increasing fishing, the average length and weight of the fish decreases. Data on the decline in the average length and weight of anchovy of the successive recruitment classes have been given in section 4. An attempt was made to use these data to determine the total mortality rates of the recruit classes. An equation relating average weight to the mortality rate is given e.g. by Gulland (1964). Data on most of the parameters used in the equation are available. It is, however, difficult to determine the average age of recruitment of the anchovy, because of the complicated recruitment pattern mentioned in section 2. It also appeared that the method is extremely sensitive to small differences in the estimate of the average age of recruitment. It was, therefore, impossible to use this method to determine the total mortality rate in this case.

6.5 Evidence on mortality obtained from the otoliths

The problems of age-determination from the ring structures in the otoliths, the earbones, of the anchovy are being studied by Einarsson and collaborators. Preliminary results of their studies were made available for this report. The main features of the age-determination problems in anchovy otoliths are:

a) It is possible to distinguish and count the number of rings in the anchovy otoliths.

b) Although it seems probable that normally two rings are found each year, this preliminary conclusion is still subject to some doubt.

c) The periods in which the rings are formed are not yet wholly established, and seem to vary from year to year and between areas.

d) It is not yet clear what is the difference, if any, in ring number between fish born from the summer and from the winter spawning.

Because of these difficulties, it was not yet possible clearly to distinguish the different yearclasses in the samples, and for this reason the data could not yet be used to determine the total mortality values.

However, the relative distributions of the numbers of rings in the sampled fish shown in fig. 7 for samples from Callao and from Chimbote, clearly demonstrate that the relative abundance of the fish with more than two

rings in the otoliths has decreased greatly from 1961 to 1964.

This again indicates that the total mortality has greatly increased duri this period.

7. Discussion and conclusions

The analyses carried out in the previous sections have provided a set of impor tant results.

Firstly, the section on general statistics showed that the increase in fishing of the anchovy stocks has been accompanied by an increase in the total landings and a decrease in the catch per unit of effort, i.e. in the catch per standard time of a bo of standard capacity and efficiency.

Both the total landings and the catch per unit of effort are, however, affecte by fluctuations in the size of the annual recruitment of young fish to the fishable stocks, and by fluctuations in the availability of the fishable stocks to the fishery The present study gave no evidence that fluctuations in availability have played a major role during the period considered in this report. Nevertheless, the possibilit cannot be excluded that some of the data have been affected by undetected availabilit changes and that the conclusions will have to be modified when a longer series of dat become available. On the other hand, it was possible to measure the fluctuations in the annual recruitment for the years 1961-1964, and this provided a means to separate the effects of fishing from the effects of changes in recruitment in the years 1961-1964. It appeared from these data that the increase in fishing effort from 1962 to 1963, an increase by a factor of about 1.5, led to an increase in the total landings by a factor of about 1.3, but that the increase in the fleet above the level of 1963 did not in itself result in any further increase in the total landings. This means that the same high catch of over 8 million tons could have been obtained if the fleet had remained at the 1963 level, and that in that case the catches per ship would have been higher. The rise in the landings from 1963 to 1964 has been due only to the good recruitment of young fish in 1964.

In order to verify and strengthen this conclusion, another approach along the same principles involved relating the total catch of one recruit class to the size of the recruitment and the total fishing effort exerted on that class during the major part of its life-span.

This analysis gave as a result that the rise in fishing effort exerted on the recruit class of 1962 in comparison with that of 1961 did increase the landings per unit of recruitment, but that the further increase in effort exerted on the 1963 recruit class only resulted in a relatively small raise in the landings. The still higher effort to which the 1964 recruit class was exposed did not cause any increase but rather a slight decrease in the catch per unit of recruitment.

Both results agree in showing that the increase in effort above the level of that occurring in 1963 has not resulted in an increase in total landings.

Most of these results have been based on effort data in which allowance has be made for the increase in size and efficiency of the ships. It has been explained in section 3.2 that the effort data obtained in this way are the best ones available at present. It is, however, worthwhile to consider in how far our conclusions may have been affected by a bias in the effort estimates.

If the increase in fishing effort in the period under consideration has been overestimated, then the figures for catch per unit effort, for abundance and for recruitment have been underestimated in the later years. This would mean that the

crease in the abundance of the fish stock would have been less than that shown in ble 5, but that the yield per unit of recruitment would have been lower in the most cent years than shown in the tables 7, 8 and 9. The latter would imply that the vel of effort giving the optimum catch would already have been passed.

On the other hand, if the increase in fishing effort has been underestimated, en the decrease in abundance of the fish and in the catch per unit effort has been en more severe than shown in table 5, even although in that case the data of yield r unit of recruitment would show that the level of optimum total yield has not yet en reached.

Neither of these combinations seems very likely, and for the time being the fort estimates can be taken as approximately correct. If, however, our estimates ntain some bias, then it can be concluded on the above considerations and on the owledge of the biology of the anchovy as dealt with in the next paragraphs, that it more likely that the increase in fishing effort has been underestimated than that has been overestimated.

In section 6 we attempted to arrive at estimates of mortality rates. The ratio tween the fishing mortality rate and the total mortality rate was estimated on the sis of predation as being below 0.75; and on the basis of numbers of fish caught, of the order of 0.67 in the year 1964. This means that the fishing mortality rate 1964 is estimated at about 2 times the natural mortality rate.

It has not yet been possible to arrive at absolute values for the mortality tes. Nevertheless, the important decrease in average size of the fish landed, and e information on the distribution of the number of rings in the otolith samples ggest that the increase in total mortality in recent years has been substantial, and at it has reached a fairly high level.

Sufficient data are not yet available to determine the theoretical yield curve of e anchovy with precision. However, the existing information on the growth characte-stics of the anchovy (a high K of about 1.7 and a L_∞ of 15 cm), on the relative rge size at recruitment in relation to the theoretical maximum length (average size recruitment at least 10 cm and probably rather more, or a ratio to theoretical ximum length of 2/3 or more), and on mortality, suggest a yield curve which is mpatible with the results of the analysis of the catch data.

If all available information is considered together, the conclusion can be drawn at the fishing effort has reached such a level that further increase of the effort ll result in only a small increase in total catch, if any. In other words, the vel of the total fishing effort is such that with the present average recruit size the fish, the anchovy stock is exploited to about its maximum sustainable yield.

A review of theoretical yield functions (Beverton and Holt, 1964) for the most hely biological values of growth, size at recruitment and mortality, shows that increase in the minimum size of the fish caught will at most result in only a small ase in total catch. This is because once the anchovy has reached a size of over , the growth in weight is relatively slow in comparison to the rate of natural rtality. Leaving the fish in the sea until they have reached a greater size increases weight per fish but decreases the number of fish caught, because of the natural rtality, with the result that the total weight is only slightly increased above the iginal level.

In theory, a more important gain in total weight could be obtained by a greater crease in the minimum size of the fish, if at the same time the total fishing effort re to be increased considerably. This, however, would mean such a decrease in catch r unit of effort that this approach is unrealistic and can be disregarded.

The question may be asked whether protection of small fish, although not materially changing the total weight of the catch would have a beneficial effect on the industry because it would result in a greater average size of the anchovy in the landings. It is a well-known fact that a certain quantity of adult fish gives a higher production of fishmeal and oil than the same weight of small fish. This would in itself lead to a higher meal-and oil-production. It is, however, difficult to envisage any method of protecting the small fish without at the same time losing a quantity of adult ones. For instance, enforcing a larger mesh size of the seine nets is probably impracticable because enmeshing may become a most difficult problem. Secondly, the period of main recruitment of small fish, January-June, is a period in which also substantial catches of adult fish from the previous recruit-class are made, of which a part will be lost if a closed season during the whole or part of this period would be established. A third method, the enforcement of a minimum landing size for the fish, would not really prevent small fish from being caught. As far as such small fish is thrown back in the sea this would mean a loss because these fish will not have survived the treatment. To some extent the fishermen may be able to avoid shoals with a high percentage of small fish. Because, however, the shoals in general consist of a mixture of small and big fish, this again would mean a loss of adult fish. Therefore, although in theory the protection of the small fish presently caught might possibly lead to some small increase in the total weight of the catch, in practice it probably leads to a decrease in weight caught due to the difficulties explained above. The extent of this decrease cannot be determined without more precise knowledge of the rates of fishing and natural mortality, and in the case of a minimum landing size also on more knowledge of the size-composition of the different shoals and of the extent to which shoals with many small fish can and will be avoided. It is therefore, impossible at this stage to determine whether the advantage of a greater average size of the fish in the catches as a result of measures of protection of small fish will be greater than the loss due to the probable decrease in total weight of the landings.

A picture of the theoretical relationship between total fishing effort and the total yield as well as the yield per unit of effort under conditions which probably apply to the anchovy stock, is given in fig. 8. If we assume that the present effort is at such a level that it gives nearly the maximum possible yield, we can see from the graph which kind of changes in total catch and in catch per unit effort will result from a change in the fishing effort.

It must be stressed that the conclusions reached here should be considered as subject to revision. The data on which the conclusions have been based cover only a short period of time, and some essential biological data for a complete analysis are still lacking. Continued investigations are necessary both in order to provide a more firm basis for the conclusions, and also to follow the future happenings in the stocks. In this connection it should be emphasized that it would be of the greatest importance if the difficult problem of the age-determination of the anchovy could be solved.

Another reservation concerns the structure of the anchovy population along the Peruvian coast and the degree to which our findings, which are based mainly on data from the region Callao to Chimbote, are applicable to the total fishing industry. As mentioned in section 2, data on growth, size and fluctuations in recruitment indicate population homogeneity for the whole coast, but one meristic character shows a difference between the southern ports and the region Callao - Chimbote. This may mean that a complete mixing of the fish does not occur over the whole region and consequently that fishing in one region does not affect the stock to the same degree in all regions

cause the series of data is too short it has not been possible to make an analysis of e effects of fishing on the stock for the port of Ilo separately, comparable to that the north. The length-abundance curves (see fig.1) indicate, however, that a decline the abundance of the adult fish has occurred also in this port, and the catch per unit effort listed in table 5, also demonstrates a decrease which is similar to that of e northern zone. Until further data become available, the conclusions regarding the ate of the stock therefore be taken as representing the whole Peruvian stock.

Notwithstanding these reservations, it is believed that the present conclusions e sufficiently documented to form a basis for decisions on a policy of management. particular, it can be stated that if in fact the yield has not quite reached its ximum, still an increase in effort to obtain this rather small gain in total catch uld be accompanied by such a decline in catch per unit of effort that this does not em to be advisable.

One important question has not yet been discussed. It is clear that the decrease abundance caused by fishing also results in a decrease in numbers of eggs produced the spawning stocks. However, it is known from many fisheries that under normal rcumstances the production of eggs is so much higher than what is needed to ensure e normal recruitment, that a decrease in egg-production does not affect this recruitment. In most fish species recruitment will diminish only when the stock of adult sh is reduced to a very low level. To what level the stock can be reduced before e recruitment is affected will be different for each species, and little is known out this. The study of the anchovy stocks has up till now given no indication that is danger point has already been reached or approached. If, however, the recruitment the anchovy is in fact already adversely affected by the present rate of fishing, e need for reduction of the total fishing effort would be more urgent than concluded ove, and such reduction would thus avoid a decrease (possibly severe), which otherwise ght occur in the landings. It is therefore, of great importance that this question kept continuously under review.

This report only deals with the effects of fishing, and the conclusions only apply the relation between fishing effort and the yield of the available recruits. The ld curves shown in fig.8 show the relation between effort and yield or yield per it of effort for a given number of recruits. This means that if recruitment is twice high as normal, the catch and the catch per unit effort of that recruit class will so be twice as high, and if recruitment is only half the normal, the catches will so be half. However, in all situations about the same total effort will give the ximum catch from the available stock in the sea. Adaptation of effort to the natural uctuations in abundance of the recruit-class in each year will, therefore, not ult in a higher average total catch.

How recruitment is affected by natural circumstances, and how such circumstances l change in future years, is unknown and cannot be forecast. Also, availability of fish may vary or change, and little is known as yet about the effects of phenomena h as "El Niño".

It may, however, be possible to give a prognosis of the abundance of the adult h of a recruit-class based on the evaluation of the recruit-strength obtained when new class first enters the fishery in January to June each year. Such a prognosis ld not cover the whole abundance of the fish for the following season (October same r to September next year), because the next following recruit-class is also of some portance for the overall abundance, but it could give a valuable indication of the er of magnitude of the total catch.

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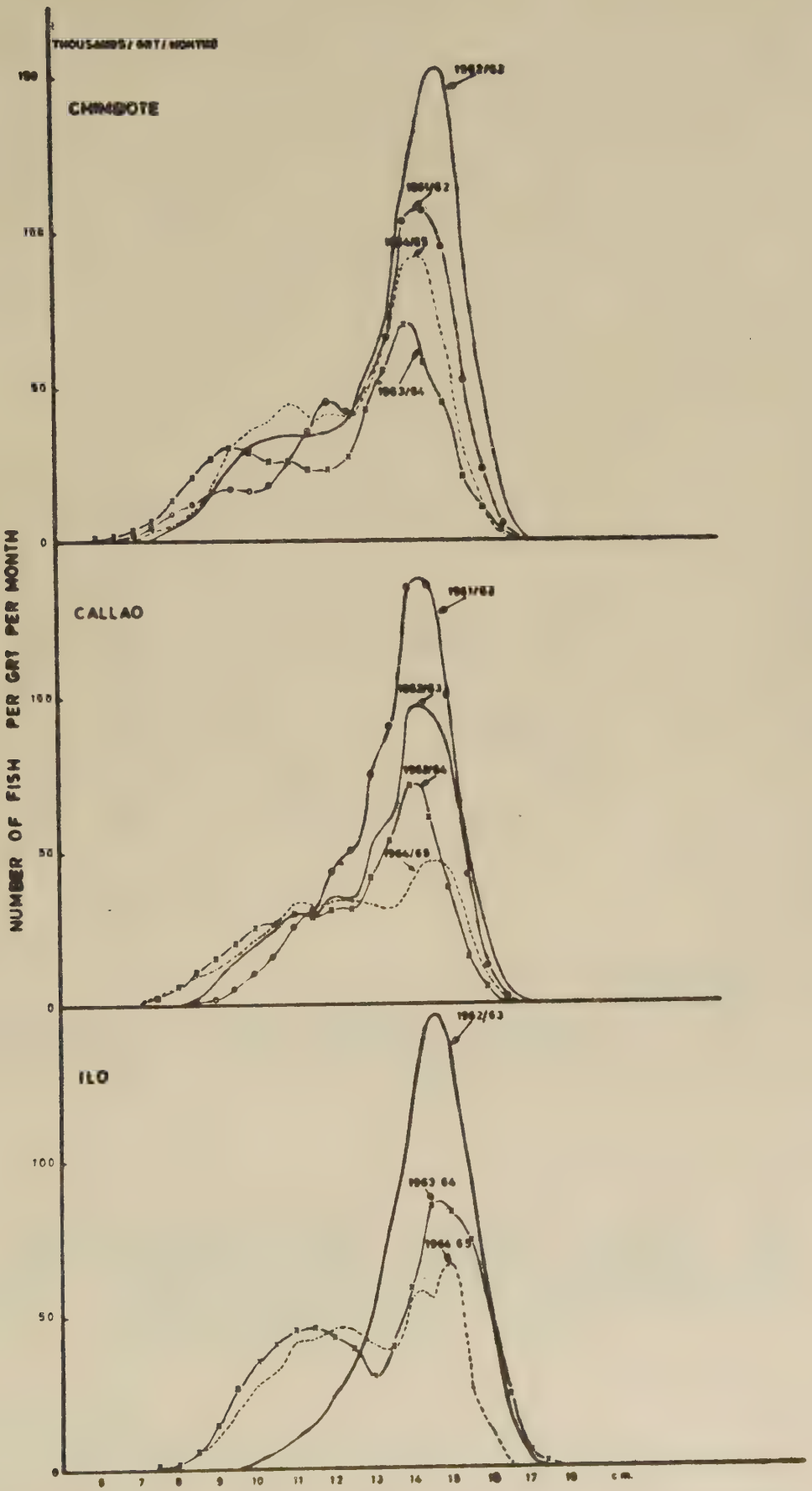

Fig. 1 - Annual length-abundance curves. Chimbote, Callao and Ilo, March 1961 to February 1962, etc.

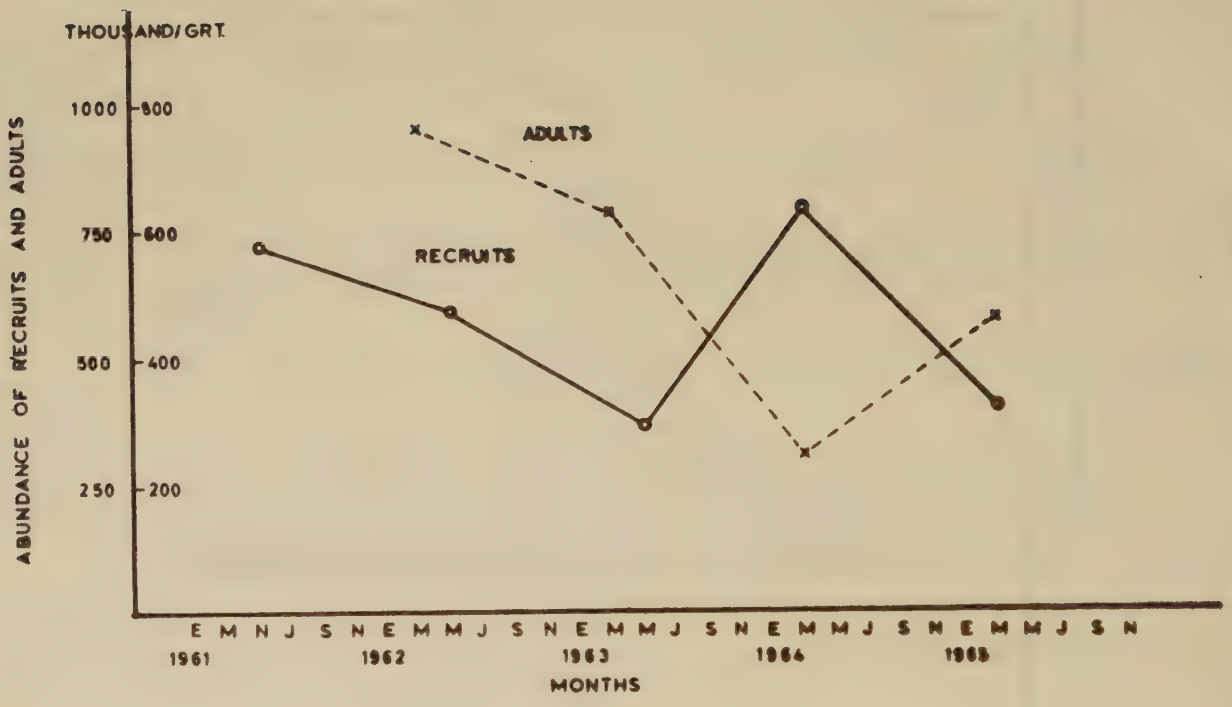

Fig.2 - Estimated abundance of recruit-groups and adult fish group 1961-1965. Means of Callao and Chimbote.

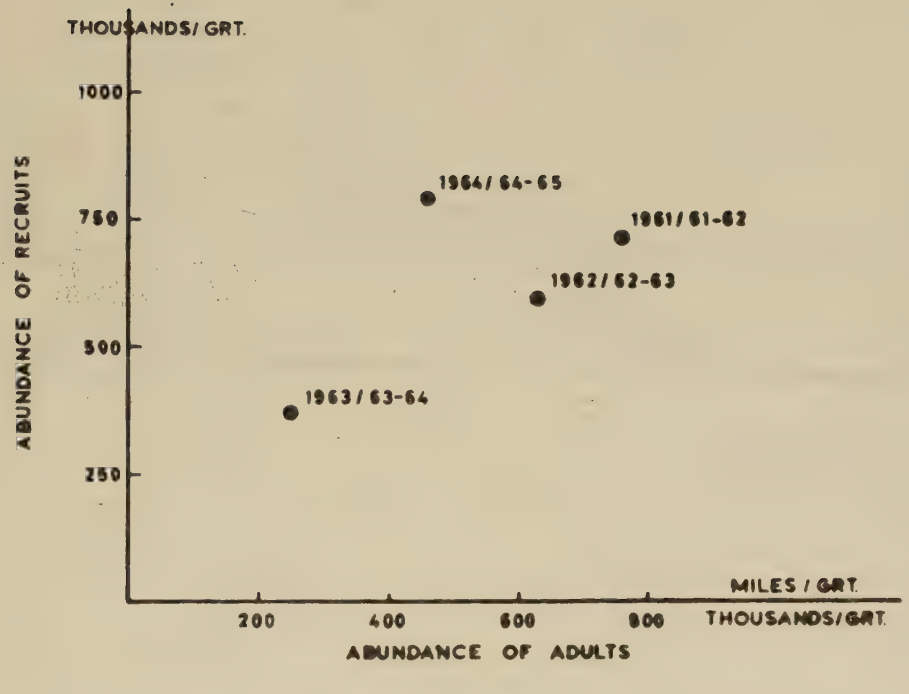

Fig.3 - Plots of recruit-abundance one year against the abundance of the adult fish group the following season. Means of Callao and Chimbote.

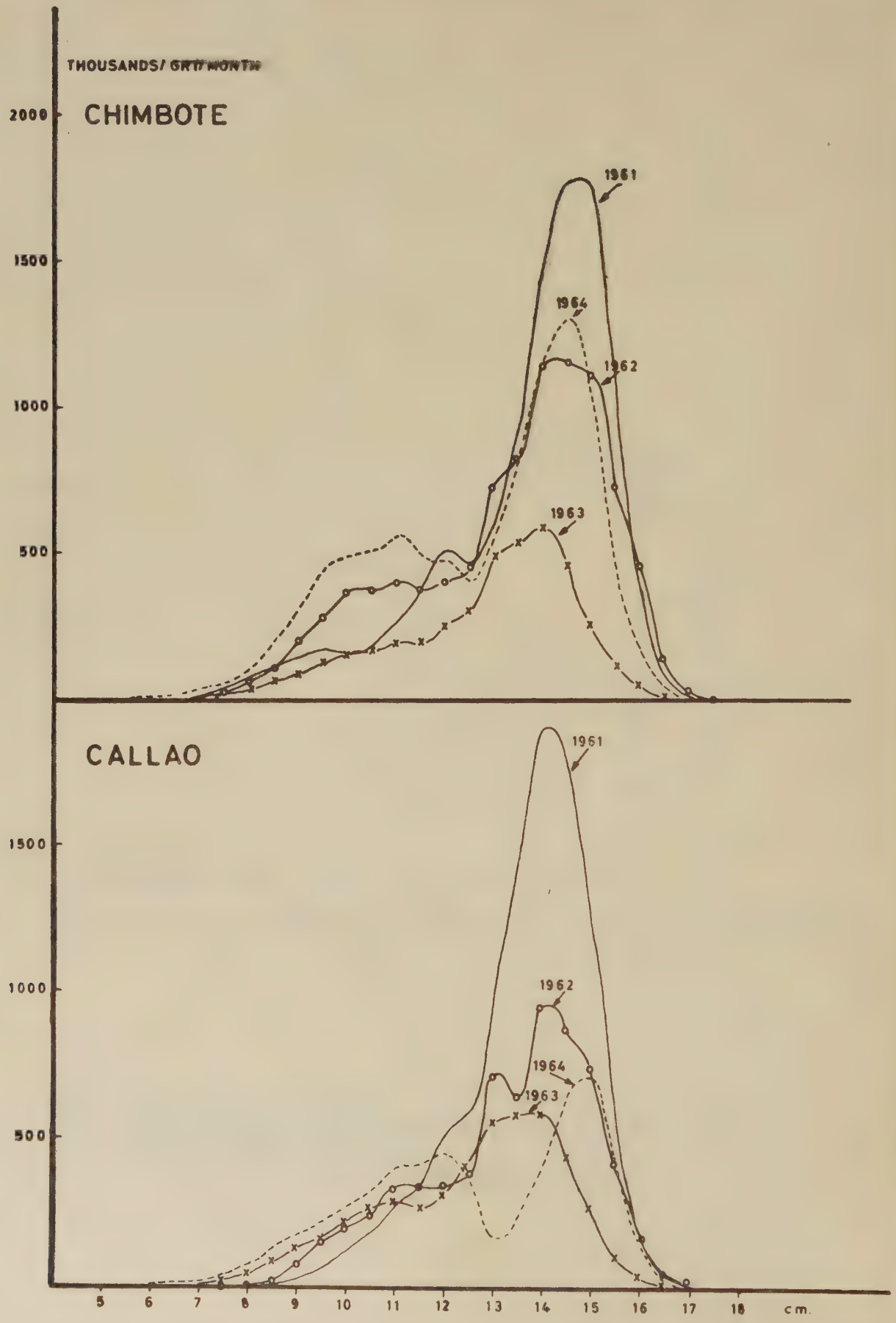

Fig.4 - Length-abundance curves of recruit classes identified by size limits in frequency-distributions. Chimbote and Callao.

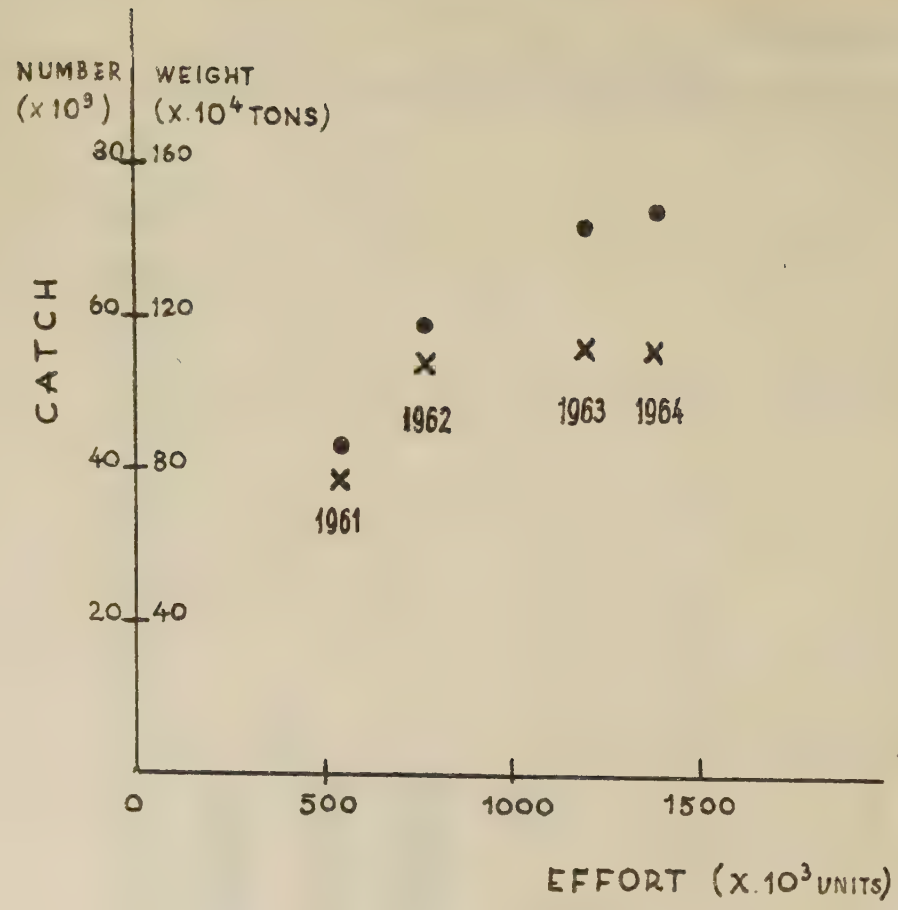

Fig. 5 - Plots of total catch by numbers and weight per unit of recruitment against effort. Catch data from length-catch curves. Total region Callao to Chimbote.
• Number x Weight

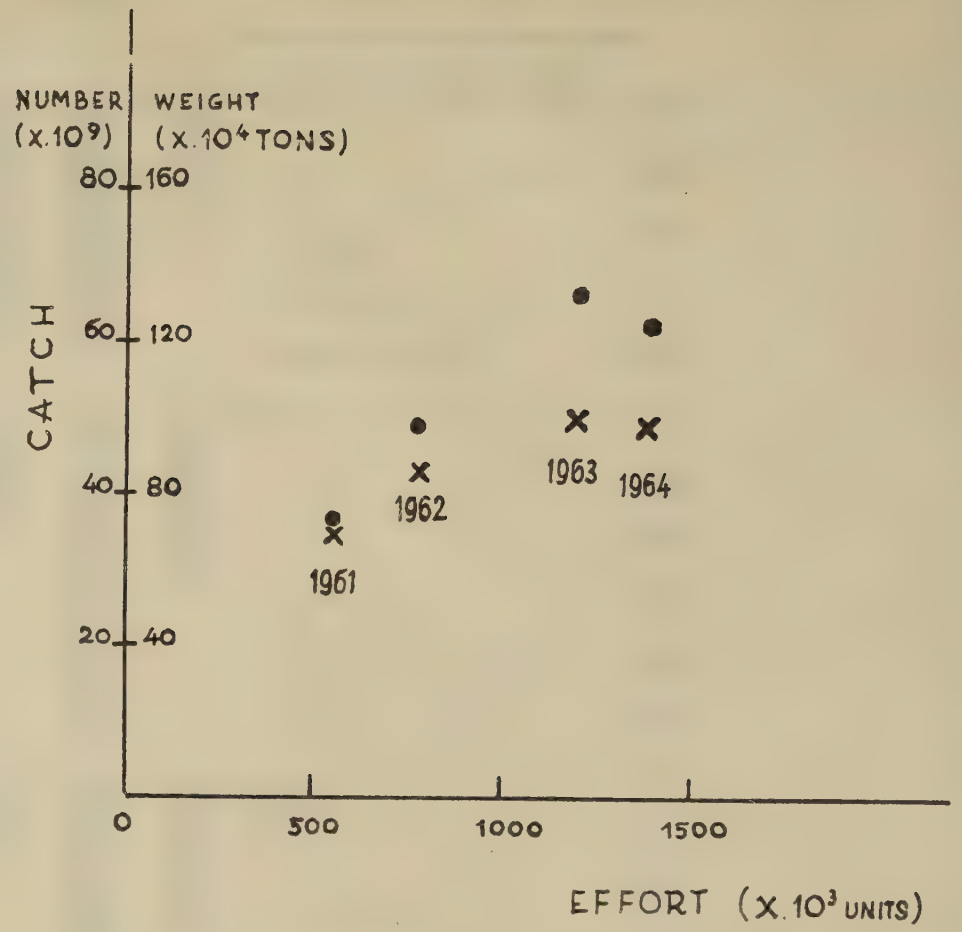

Fig.6 - Plots of total estimated catch by numbers and weight per unit of recruitment against effort. Catch from monthly compiled abundance data, for total region Callao to Chimbote.
• Number x Weight

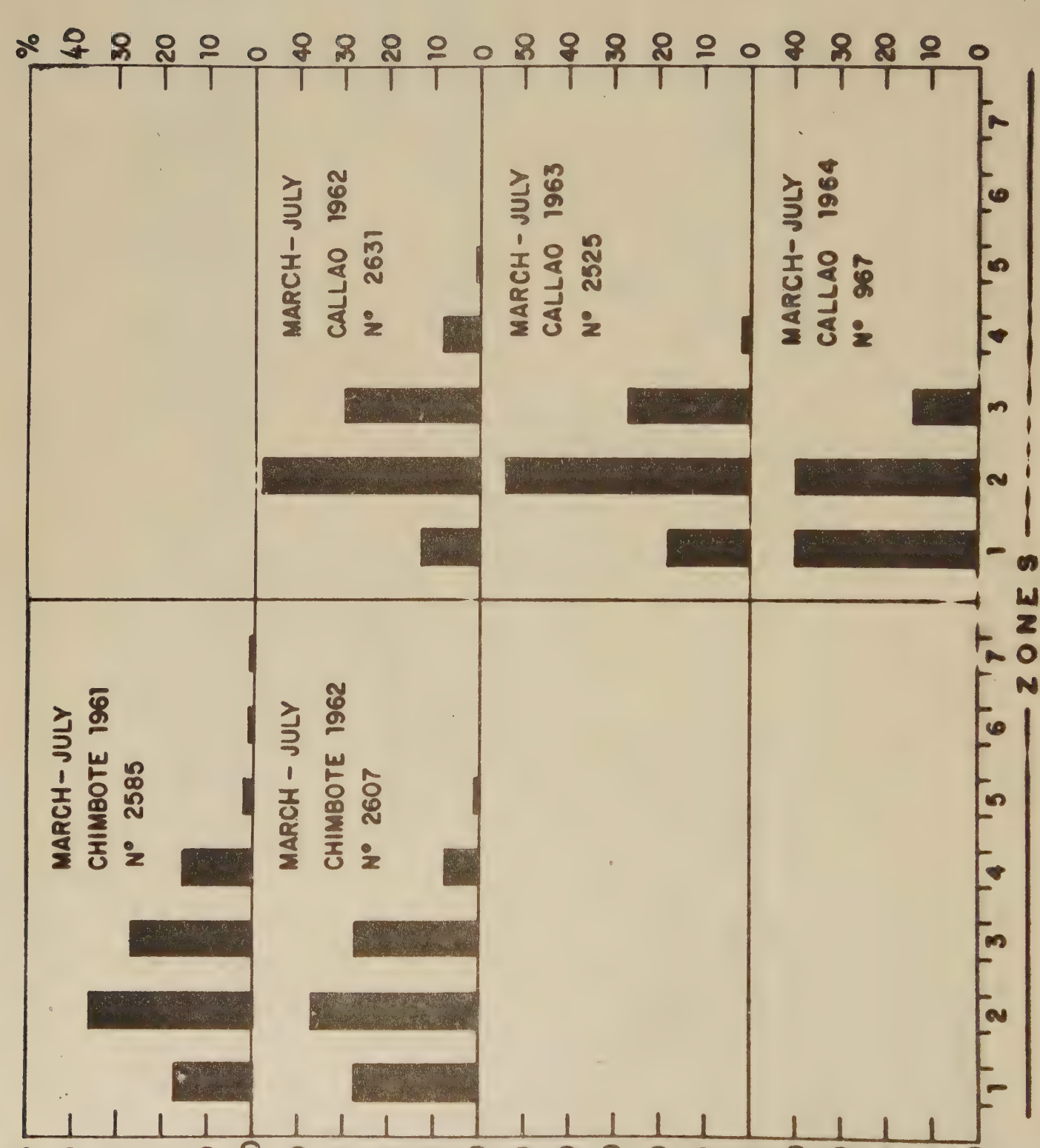

Fig.7 - Frequency distribution of otolith zones in samples from Chimbote 1961 and 1962 and

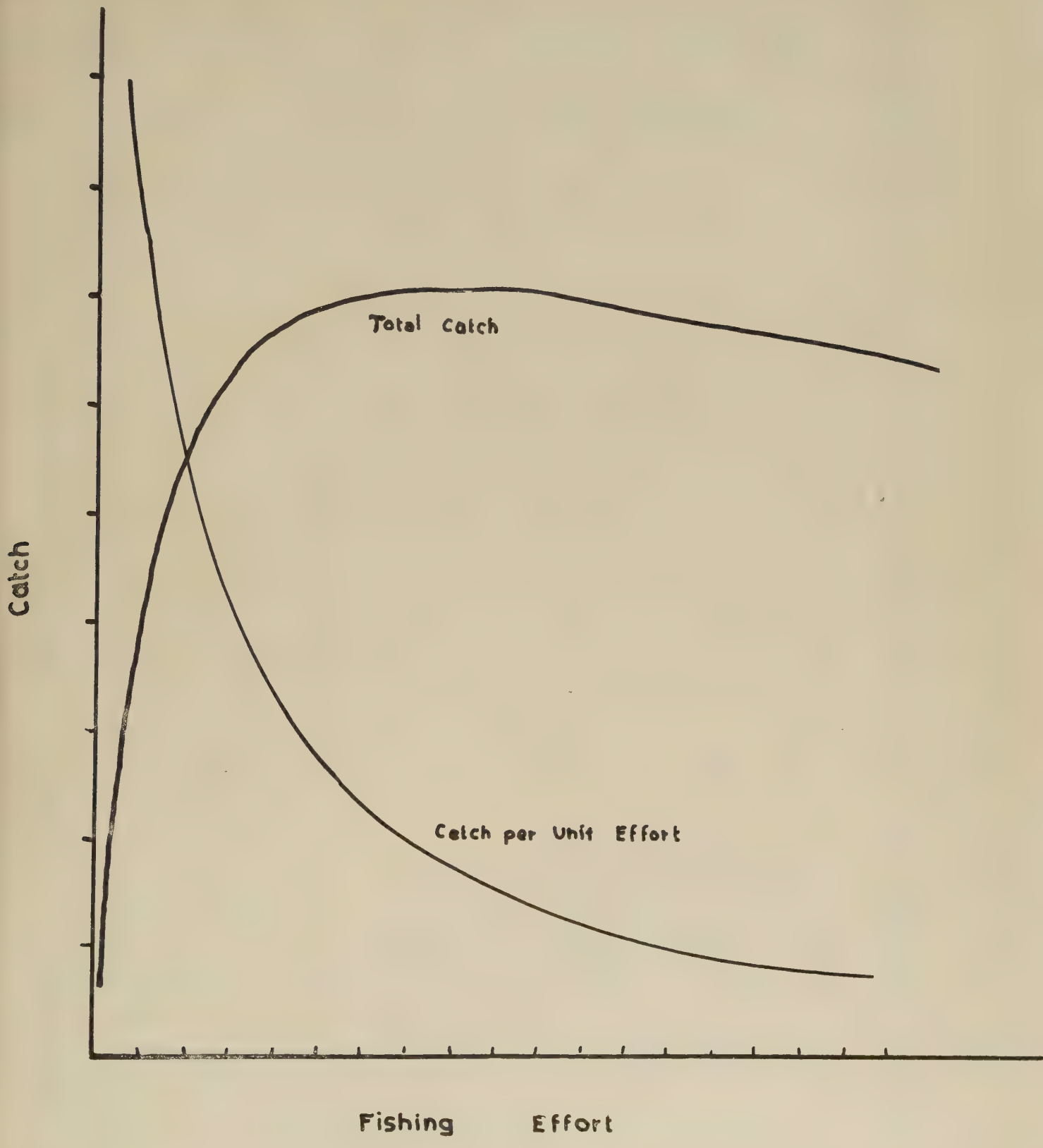

Fig.8 - Relationship between catch effort and catch per unit of effort for biological conditions that probably apply to the anchovy population.

and monthly abundance indices by numbers

	CHIMBOTE 1961										CHIMBOTE 1962											
cm	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5																						
.5											2											
6											3	1										
.5	1										16	5										
7	2	6	1	1							14	15	1									
.5	2	23	7	2							20	25	4		1							
8	5	33	25	7		1					24	44	19	1	3	1	1					
.5	5	30	45	19	2	11					26	52	31	7	13	4	2					1
9	2	27	65	38	19	22				2	21	62	45	23	33	21	16					1
.5	2	19	65	49	50	52	1			1	19	51	56	58	39	44	25	1				1
10	17	13	53	41	56	63	5			4	16	40	55	80	53	65	48	2	6		1	
.5	67	17	50	37	48	43	7			9	17	27	42	77	58	83	45	11	20			
11	114	64	60	33	32	37	12		2	13	25	25	29	74	64	90	62	23	40	2		
.5	124	148	68	42	27	41	12		4	19	18	26	25	58	59	84	65	34	50	15		1
12	87	169	87	76	57	75	22	1	7	45	13	23	20	45	54	74	64	62	58	29	3	6
.5	57	83	75	84	75	117	41	2	15	79	21	24	26	35	34	50	54	75	70	32	13	20
13	68	54	68	93	96	140	88	10	26	121	49	50	37	35	42	45	49	93	94	37	53	56
.5	68	51	64	78	94	107	145	39	78	177	79	66	69	47	43	52	48	99	80	37	112	100
14	96	66	74	101	119	101	192	121	185	241	185	131	142	77	85	78	88	129	108	69	205	170
.5	96	62	71	106	116	78	185	213	237	168	210	165	187	134	126	113	139	145	129	110	204	165
15	100	65	59	103	111	68	163	292	241	86	143	112	140	141	160	115	164	185	183	223	182	190
.5	58	48	41	58	63	28	80	194	130	26	55	40	54	71	89	57	91	100	108	216	117	139
16	26	21	16	24	29	12	37	101	62	8	20	13	15	31	34	20	34	35	46	172	80	92
.5	5	4	4	6	5	3	9	24	11	1	4	2	2	6	9	4	5	5	8	49	25	30
17			1	1			2	2	2			1	1		1			1		9	4	6
.5																					1	1
18																						
.5																						
Totals	1000	1001	999	999	999	999	1001	999	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	999
Abundance x 10^3	695	1093	1063	868	473	264	304	591	1289	1374	332	610	1099	1170	1502	1139	659	464	548	668	1034	1037
Catch x 10^6	9671	8954	9447	6455	4229	1698	3315	4704	9006	10248	3130	9991	9967	11631	13671	12103	7849	5946	6641	9946	11927	12968

CHIMBOTE 1963

Length Frequency (Per Mille)

cm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	De
5												
.5												
6											5	
.5					1						4	
7	2				6						17	1
.5	8				11	1					16	2
8	21		1		20	4					13	4
.5	23		3	1	26	13					9	6
9	20		7	5	40	31	3				3	7
.5	11		13	12	74	56	4				2	7
10	9		15	14	91	77	26			1		4
.5	5		15	11	98	83	41	1		1		2
11	2		14	9	114	99	63	2	2	5		1
.5	7		11	8	101	107	72	4	10	25	1	
12	38		12	6	77	98	94	15	47	67	4	
.5	90	2	18	21	43	69	84	29	91	142	37	1
13	139	20	50	71	36	46	104	57	127	200	146	6
.5	139	47	124	124	45	44	80	66	144	164	200	12
14	167	122	212	209	54	57	108	130	176	166	226	18
.5	140	175	196	209	49	59	110	182	172	119	150	13
15	95	234	162	162	53	72	120	237	137	66	104	6
.5	52	177	80	78	34	46	61	156	62	29	40	1
16	23	152	49	47	19	26	24	92	27	12	19	
.5	7	56	16	11	7	9	6	23	5	2	3	
17	1	13	3	2	1	2		5	1	1	1	
.5		1						1				
18												
.5												
Totals	999	999	1001	1000	1000	999	1000	1000	1001	1000	1000	100
Abundance x 10^3												
	1168		487	637	854	565	342	130	231	336	394	81
Catch x 10^6												
	16057	3772	8986	12044	14973	9985	6556	2148	4253	4954	6797	1777

CHIMBOTE 1964

Length Frequency (Per Mille)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5	2											
	6											
5	13										2	3
	27	2					1			1	8	6
5	39	10				3	2				14	12
	56	35	2	1		6	3	1		1	10	20
5	92	70	12	5		16	9	3			12	27
	100	105	46	14		25	25	8			7	33
5	103	111	101	35	2	26	50	12			3	36
	74	108	142	59	9	20	58	14			2	27
5	51	99	146	90	32	15	67	24	1		1	18
	38	90	145	134	72	16	62	35	1			10
5	29	62	108	136	114	30	46	35	2	2		6
	25	54	76	150	175	69	40	39	5	11	1	3
5	45	45	50	113	183	113	63	47	18	36	4	3
	79	56	40	102	162	176	101	72	64	109	22	15
5	90	54	41	68	105	178	155	117	135	193	104	67
	71	43	38	48	83	160	154	171	221	221	222	158
5	36	30	30	25	35	89	105	202	264	204	281	203
	18	19	15	14	20	42	43	134	192	144	192	196
5	5	5	6	4	6	13	12	60	69	57	85	104
	2	1	2	2	1	3	5	22	24	18	25	44
5	1	1						4	4	2	6	8
												1
5												
5												
ls	999	1000	1000	1000	999	1000	1001	1000	1000	999	1001	1001
dance x 10^3												
	1210	823	1499	1093	539	411	416	302	292	417	748	1156
h x 10^6												
	28431	18044	32763	26404	14764	10738	12794	8496	9420	10066	17262	21549

CHIMBOTE 1965

Length Frequency (Per Mille)

cm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5												
.5												
6												
.5	1				1							
7	4				5							
.5	10		1		6							
8	18	3	5	2	5							
.5	37	16	15	11	9							
9	60	35	39	35	17							
.5	81	62	68	60	35							
10	62	78	59	59	53							
.5	47	94	50	68	86							
11	29	68	52	73	118							
.5	21	47	41	71	126							
12	17	38	33	52	97							
.5	25	52	31	42	65							
13	37	68	31	40	53							
.5	90	112	55	60	58							
14	145	119	105	98	76							
.5	149	90	164	139	94							
15	99	68	146	114	56							
.5	48	32	71	54	27							
16	16	15	27	18	10							
.5	4	3	5	4	3							
17			1									
.5												
18												
.5												
Totals	1000	1000	999	1000	1000							
Abundance x 10^3	948		687	838	693							
Catch x 10^6	23646	1810	19644	25699	19548							

Length Frequency (Per Mille)

cm	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5																						
.5																						
6																						
.5																						
7																						
.5		1								1												1
8		1													1							4
.5	1	1	2	1						1					3	11	2					10
9	7	4	5	4	1					1		2	1	2	14	51	18					9
.5	26	8	13	10	6	1				1	3	5	4	3	29	83	46					8
10	37	15	27	27	27	6				1	4	9	12	3	45	92	62	4				2
.5	40	19	37	43	57	20	2	2			5	19	21	9	58	96	73	18	3			2
11	43	28	56	79	85	44	4	10			7	23	36	19	83	94	92	44	25	1		1
.5	47	34	81	99	66	49	12	25	4		7	19	41	25	83	74	81	56	49	12	5	
12	69	61	114	116	65	62	27	56	16	5	18	22	47	28	88	71	84	89	88	66	21	2
.5	75	68	108	106	66	64	41	73	44	20	33	39	40	27	63	50	61	86	87	145	59	12
13	96	110	135	119	104	71	83	101	96	51	60	88	57	47	81	58	73	108	94	185	118	51
.5	108	124	116	111	124	92	142	130	128	106	94	135	76	85	95	68	90	108	74	102	126	100
14	163	182	136	117	171	160	202	168	201	230	190	206	158	211	140	100	142	151	102	120	177	158
.5	153	171	94	90	123	180	223	182	225	267	236	224	192	243	118	74	98	152	154	109	169	183
15	93	121	53	55	78	152	165	148	186	200	199	138	177	193	65	52	52	119	159	138	161	214
.5	35	39	17	18	21	70	76	79	77	87	105	55	99	76	26	19	20	42	107	79	102	159
16	6	12	5	4	5	25	20	21	19	25	33	14	31	25	7	6	5	17	43	32	48	69
.5	1	1		1		4	2	5	3	4	5	2	6	4	1	1	1	5	14	10	12	13
17											1		1					1	1	1	1	2
.5																						
18																						
.5																						
Totals	1000	1000	999	1000	999	1000	999	1000	999	1000	1000	1000	999	1000	1000	1000	1000	1000	1000	1000	999	1000
Abundance x 10^3	616	770	1234	1020	661	492	336	728	1000	1015	832	579	570	715	1186	884	682	430	257	413	612	644
Catch x 10^6	7095	7627	13376	11391	7895	6537	4334	7995	10827	11193	9906	6923	7497	8680	16101	13204	9499	5439	5219	6393	10381	10864

CALLAO 1963

Length Frequency (Per Mille)

cm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	D
5												
.5												
6												
.5												
7			1								1	
.5			6		2					4	2	
8			23	1	4	2	3			2	8	
.5	2		55	10	7	7	5		1	4	18	
9	9		54	31	14	14	9	4	3	1	24	
.5	21		48	66	19	27	21	9	6	1	22	
10	36		38	93	30	42	33	23	13	3	24	
.5	40	12	44	116	34	74	34	43	19	5	18	
11	25	19	44	101	60	90	48	62	36	13	10	
.5	12	15	33	59	63	100	57	74	48	29	7	
12	9	15	36	47	53	90	102	90	71	67	20	
.5	17	22	63	26	35	60	98	106	96	116	58	
13	74	86	125	55	36	59	93	114	95	152	102	
.5	113	135	116	87	84	79	89	107	111	213	154	
14	165	191	129	129	169	125	129	141	167	185	214	1
.5	146	188	84	100	183	110	134	122	162	120	170	1
15	158	151	63	51	130	72	90	69	103	60	98	1
.5	108	117	27	20	56	35	41	26	46	17	36	
16	52	40	8	6	18	12	12	7	18	6	12	
.5	12	9	3	2	3	2	2	1	5		2	
17	1									1		
.5												
18												
.5												
Totals	1000	1000	1000	1000	1000	1000	1000	999	1000	999	1000	10
Abundance x 10^3												
	710		558	703	903	540	194	345	265	354	446	4
Catch x 10^6												
	14286	1279	11456	13982	17712	11077	2580	6064	4537	3933	11003	95

CALLAO 1964

Length Frequency (Per Mille)

m	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
.5												
		1										1
.5	2	4										2
	8	10	1		2	2						5
.5	6	28	5		2	7	1			1	1	13
	7	45	13	1	2	17	5			1	1	13
.5	9	76	30	3	1	26	13			1	1	18
	19	98	53	10	2	15	18				2	17
.5	21	107	85	26	6	11	12				5	22
	32	104	110	67	26	17	11	2			2	44
.5	39	72	113	107	57	45	12	5			2	50
	55	63	104	132	111	102	37	13				69
.5	77	61	77	118	138	126	84	42				49
	98	51	85	102	143	140	154	48	1	1	2	35
.5	104	49	83	113	130	151	171	49	18	5	12	23
	127	58	73	107	115	124	147	55	68	19	33	36
.5	135	62	49	73	92	84	114	102	152	68	78	72
	124	56	50	58	78	63	103	188	225	169	141	115
.5	77	34	39	42	48	37	65	224	237	276	250	168
	44	16	22	28	32	22	35	166	192	264	258	151
.5	13	4	6	10	11	8	14	72	71	136	151	75
	2	1	1	3	3	2	5	27	29	49	50	20
.5								6	6	8	10	2
									1	2	1	
.5												
.5												
tals	999	1000	999	1000	999	999	1001	999	1000	1000	1000	1000
ndance x 10^3												
	662	697	777	696	559	414	449	40	112	377	382	354
tch x 10^6												
	15639	16015	20149	17371	13963	4511	5852	771	96	8646	9993	5184

CALLAO 1965

Length Frequency (Per Mille)

cm	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5												
.5												
6				1								
.5	2	1	1		1							
7	9	1	2	3	1							
.5	29	5	2	11	7							
8	66	14	6	14	12							
.5	89	20	5	15	18							
9	101	34	13	17	23							
.5	91	58	17	23	22							
10	79	66	32	41	23							
.5	69	72	48	56	42							
11	57	74	64	78	56							
.5	41	59	71	78	72							
12	14	46	59	78	106							
.5	11	36	52	60	115							
13	10	29	42	43	100							
.5	17	46	45	36	63							
14	29	88	88	66	61							
.5	66	124	153	111	83							
15	105	123	157	134	99							
.5	75	72	104	96	69							
16	32	27	35	33	24							
.5	5	4	4	6	3							
17	2	1										
.5												
18												
.5												
Totals	999	1000	1000	1000	1000							
Abundance x 10^3	637	576	717	417	595							
Catch x 10^6	12988	8375	16168	5921	9536							

ANNEX TABLE II

Size limits used in identifying the recruit classes in the monthly length-frequency compositions

C H I M B O T E

	Recruit Class 1961		Recruit Class 1962		Recruit Class 1963		Recruit Class 1964	
	1961	1962	1962	1963	1963	1964	1964	1965
Jan		≥ 13.0	≤ 12.5 ≥ 12.0		≤ 11.5 ≥ 12.0		≤ 11.5 ≥ 13.0	
Feb		≥ 13.0	≤ 12.5 ≥ 12.5		≤ 12.0 ≥ 12.5		≤ 12.0 ≥ 13.0	
Mar	≤ 12.5 ≥ 13.0		≤ 12.5 ≥ 12.5		≤ 12.0 ≥ 13.0		≤ 12.5 ≥ 13.0	
Apr	≤ 13.0 ≥ 13.5		≤ 13.0 ≥ 12.5		≤ 12.0 ≥ 14.0		≤ 13.5 ≥ 13.0	
May	≤ 13.5 ≥ 13.5		≤ 13.0 ≥ 13.0		≤ 12.5 ≥ 14.0		≤ 13.5 ≥ 13.5	
Jun	≤ 13.5 ≥ 13.5		≤ 13.0 ≥ 13.5		≤ 13.0 ≥ 14.5		≤ 14.0	
Jul	≤ 13.5 ≥ 14.0		≤ 13.5 ≥ 14.0		≤ 13.5 ≥ 14.5		≤ 14.0	
Aug	≤ 14.0 ≥ 14.0		≤ 13.5 ≥ 14.0		≤ 13.5 ≥ 15.5		≤ 15.0	
Sep	≤ 14.0 ≥ 14.0		≤ 13.5 ≥ 14.0		≤ 13.5 ≥ 15.5		≤ 15.0	
Oct	≥ 13.0		≥ 13.0		≥ 12.0		≥ 12.5	
Nov	≥ 13.0		≥ 13.0		≥ 12.0		≥ 13.0	
Dec	≥ 12.0		≥ 13.0		≥ 12.0		≥ 13.0	

Size limits used in identifying the recruit classes in the monthly length-frequency compositions

C A L L A O

	Recruit Class 1961		Recruit Class 1962		Recruit Class 1963			Recruit Class 1964		
	1961	1962	1962	1963	1962	1963	1964	1963	1964	1965
Jan		≥ 12.0	≤ 11.5	≥ 12.5		≤ 12.0	≥ 12.5		≤ 12.0	≥ 13.5
Feb		≥ 12.5	≤ 12.0	≥ 12.5		≤ 12.0	≥ 12.5		≤ 12.0	≥ 13.5
Mar	≤ 13.5	≥ 13.0	≤ 12.5	≥ 13.0		≤ 12.5	≥ 13.5		≤ 13.0	≥ 13.5
Apr	≤ 13.5	≥ 13.0	≤ 12.5	≥ 13.0		≤ 12.5	≥ 14.0		≤ 13.5	≥ 14.0
May	≤ 13.5	≥ 13.5	≤ 13.0	≥ 13.0		≤ 12.5	≥ 14.0		≤ 13.5	≥ 14.0
Jun	≤ 14.0	≥ 13.5	≤ 13.0	≥ 13.5		≤ 13.0	≥ 14.0		≤ 13.5	
Jul	≤ 14.0	≥ 13.5	≤ 13.0	≥ 14.0		≤ 13.5	≥ 14.0		≤ 13.5	
Aug	≤ 14.5	≥ 14.0	≤ 13.5	≥ 14.0		≤ 13.5	≥ 14.0		≤ 13.5	
Sep	≤ 14.5	≥ 14.0	≤ 13.5	≥ 14.0		≤ 13.5	≥ 14.0		≤ 13.5	
Oct	≥ 12.0		≥ 12.5		≤ 12.0	≥ 11.5		≤ 11.0	≥ 11.5	
Nov	≥ 12.0		≥ 12.5		≤ 12.0	≥ 12.0		≤ 11.5	≥ 12.0	
Dec	≥ 12.0		≥ 12.5		≤ 12.0	≥ 12.5		≤ 12.0	≥ 12.5	

ANNEX TABLE III

Estimated abundance of recruit groups and groups of adult fish

A. Recruits: 3 Highest months between January-July

	CHIMBOTE	CALLAO	MEAN
1961	685	759	722
1962	621	569	595
1963	401	342	372
1964	1041	550	796
1965	462	352	407

B. Adults: Mean abundance November-May

	CHIMBOTE	CALLAO	MEAN
1961/62	7874	7306	7590
1962/63	7468	5162	6315
1963/64	2840	2119	2480
1964/65	6362	2812	4587

ANNEX TABLE IV

Length - Weight relationship of the anchovy

Length in cm	Weight in g
5.5	1.0
6.0	1.1
6.5	1.5
7.0	1.9
7.5	2.4
8.0	3.0
8.5	3.7
9.0	4.4
9.5	5.3
10.0	6.3
10.5	7.4
11.0	8.6
11.5	10.0
12.0	11.5
12.5	13.2
13.0	15.1
13.5	17.1
14.0	19.3
14.5	21.7
15.0	24.3
15.5	27.1
16.0	30.1
16.5	33.3
17.0	36.8
17.5	40.4
18.0	44.5
18.5	48.8

ANNEX TABLE V

Total length catch compositions by recruit-classes, estimated total catch by numbers and weight, and mean length and weight of the fish caught. Numbers in 10^6, catch by weight in tons

	CALLAO				CHIMBOTE			
cm	1961	1962	1963	1964	1961	1962	1963	1964
6				21		23	3	184
				110	7	76	21	363
7	3	1	20	367	66	134	113	809
	9		133	793	270	242	300	1324
8	14	12	436	1437	546	565	648	2380
	51	232	1147	2677	796	994	880	4629
9	192	1100	1762	3884	1128	1905	1318	7137
	577	2124	2631	5083	1284	2765	2021	9966
10	1305	2768	3559	6753	1260	3571	2653	11207
	2007	3429	4581	7503	1520	3738	2826	11863
11	3154	4484	5034	8921	2237	4046	3317	13135
	3705	4371	4658	8926	3201	3833	3368	11828
12	5696	4838	5420	9447	3563	3637	4811	11580
	6697	6381	6598	7207	2933	4968	5735	10950
13	10778	10802	7066	7275	5205	6661	9677	13889
	16789	10720	8915	6942	7749	10514	10828	20888
14	23273	16503	10996	7874	13402	15998	12475	26727
	21913	15405	8827	11856	16102	16246	8982	29617
15	15061	13003	5365	12701	16244	15822	5399	21673
	6903	7419	1868	7839	8367	10173	2885	8943
16	2088	3003	571	2815	3388	6563	1049	3226
	398	672	68	432	670	2013	189	655
17	45	68	10	67	74	381	28	64
	4	7		1	7	31	2	4
18						1		
Total Catch N x 10^6	120662	107342	79665	120933	90009	114900	79528	223041
Total Catch tons	2146570	1913750	1186940	1789330	1735080	2141780	1268840	3397150
Mean Length cm	13.72	13.45	12.67	12.51	13.76	13.55	12.96	12.66
Mean Weight g	17.79	17.83	14.90	14.80	19.28	18.64	15.95	15.23

ANNEX TABLE VI

Total length-abundance compositions by recruit-classes, total abundance by numbers and weight, and mean weight. January one year to September next year. Unit number x 10^2 per GRT per month

	CHIMBOTE				CALLAO			
	1961	1962	1963	1964	1961	1962	1963	1964
				12				1
6		16	2	67				10
	7	80	12	155				49
7	83	140	69	348	3	1	16	161
	345	254	182	566	8	6	105	363
8	702	596	419	1027	13	12	353	658
	1028	1048	557	2003	48	167	888	1214
9	1420	1970	795	3093	175	771	1197	1688
	1637	2824	1169	4315	520	1504	1605	2148
10	1559	3597	1513	4859	1167	1969	2024	2830
	1804	3723	1600	5094	1773	2476	2567	3184
11	640	3968	1868	5581	2778	3307	2814	3952
	3773	3720	1906	4948	3285	3370	2647	4093
12	3075	3995	2426	4732	5082	3446	3191	4491
	4642	4447	2986	4046	5961	3772	4081	3747
13	6098	7267	4850	5428	9513	7119	5583	1608
	9393	8308	5322	8350	14178	6384	5788	2258
14	15185	11421	5845	11715	18947	9480	5835	3984
	17672	11518	4640	13013	17797	8698	4377	6461
15	17457	11097	2459	10131	12311	7378	2681	7006
	8957	7176	1184	4415	5595	4164	938	4389
16	3680	4630	440	1620	1665	1681	295	1539
	728	1400	79	327	307	383	37	237
17	86	259	13	33	34	42	7	33
	7	21	1	2	4	3		
18		1						
Abundance Nx10^2	103978	93476	40337	95880	101164	66133	47029	56104
Abundance kg	195970	163910	62339	149384	186860	113983	68321	86854
Weight g	18.85	17.53	15.45	15.58	18.47	17.24	14.53	15.48

(Note: This table gives the totals of the monthly length-abundance data. In order to obtain the average monthly abundance data all figures have to be divided by 21).